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ABSTRACT

This report describes activities of the PLATO Education Group (PEG), the educational research and development arm of the Computer-based Education Research Laboratory (CERL) at the University of Illinois at Urbana-Champaign. Staff, funding sources, and an overview are presented for the four projects summarized, along with additional, project-specific information. A description of the PLATO Corrections Project (PCP)--which provides inmates of Illinois adult correctional facilities with access to basic skills instruction and to instruction in several vocational and a few advanced academic areas--discusses outreach, noteworthy features and problems, curriculum development (reading, language, and mathematics), the SYS IV instructional management system, PCP instructional design research, and future plans. Qualitative interpretation of graphs for students of basic sciences and prototype microcomputer courseware for teaching high school algebra are subtopics in a description of the PLATO Mathematics Project, which is involved in courseware research, development, implementation, and evaluation in basic mathematics. Additional projects summarized are the Continuing Study of the Use of Computers in Mathematics Instruction, and the Handicap Technology Program. References are listed for each project summary. (LMM)

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Computer-based Education Research Laboratory

CERL

PLATO® EDUCATION GROUP

SUMMARY OF ACTIVITIES 1982-83

CERL REPORT E-24

FEBRUARY 1983

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PLATO EDUCATION GROUP:
Summary of Activities 1982-83

Introduction

The PLATO Education Group (PEG) is the educational research and development arm of the Computer-based Education Research Laboratory (CERL), University of Illinois at Urbana-Champaign.

The overall goal of the PLATO Education Group is to provide leadership to the computer-based education community in the areas of curriculum development, instructional research, and evaluation. More specifically...

- o discover/develop techniques for using PLATO (or more generally, computer-based education) to advantage;
- o develop corresponding computer-based materials;
- o recruit cooperating institutions and develop model programs;
- o gather data demonstrating the usefulness (or lack thereof) of the techniques;
- o write reports and journal articles based on these results.

The specific goals are interdependent, not sequential. Ultimately, the knowledge gained should contribute to the emerging discipline of computer-based education.

Martin A. Siegel, Head
PLATO Education Group
Assistant Director, CERL
February 1983

THE PLATO CORRECTIONS PROJECT

1982-83 Staff

Martin Siegel, Director; John Bryan; Jane Clapp; Catherine Daubard; Dennis M. Davis; Robert Dixon; J. Michael Felty; David Fuller; John Gilpin; Connie Kyse; Albert Liu; Dorothy O'Connell; Joan Phebus; Lindsay Reichmann; Dorothy Silver; and Robert Stevens

Funding Sources

State of Illinois, Department of Corrections; Law Enforcement Assistance Administration, U.S. Department of Justice; Illinois Law Enforcement Commission; and University of Illinois
$2,000,000 - (1975-1983)

Overview

The PLATO Corrections Project (PCP) provides inmates of Illinois adult correctional facilities with access to basic skills instruction--both a pre-GED and a GED (i.e., high school equivalency) curriculum--and to instruction in several vocational and a few advanced academic areas. Current learners are generally males in their 20s, who are economically and educationally disadvantaged, and are often members of minority groups. Given that many of these students have had negative educational experiences, PCP is committed to bolstering academic skills and also to fostering a positive attitude toward learning and increasing motivation to learn.

The set of 500 pre-GED and GED PLATO lessons (150 lessons developed by PCP) provide mastery-based instruction in reading comprehension, mathematics, and language skills to prepare individuals for the GED examination. Each lesson represents an average of 30 minutes of instruction and sometimes includes an "off-line" (i.e., time off the computer) set of work materials that complements the on-line lessons. PLATO central staff are the primary developers of the GED lessons, but other PLATO users at the University of Illinois and elsewhere in the state contribute to lesson development.

Instruction is computer-managed; i.e., each curriculum includes criterion-based pretests, instructional components, and posttests. The SYS IV Management System offers tools to assign work easily, to monitor student progress, and to maintain a log of completed lessons. Instructors have the option of obtaining student progress reports via computer terminal or on hardcopy printouts.

Outreach

The management system and curricula developed for PCP have found application in several different settings besides the prisons. Job Corps centers, high schools, middle schools, junior colleges, storefront schools, and a mental health center have all made use of the package. In addition, the Police Training Institute at the University of Illinois has used the management system in connection with their own training curriculum.

Noteworthy Features and Problems

PLATO lessons are field tested, revised, and retested before final versions are released. Students' long-term retention of subject matter objectives is effected through increasing ratio review. Genuine individualization of instruction is achieved through placement in the curriculum according to the student's skill weaknesses; routing in a given lesson is based on the task the student failed and the type of error he made (for additional features, see sections on SYS IV Instructional Management System and PCP Instructional Design Research).

It is remarkable to note that, since the beginning of the PCP Project in 1975, there has been no intentional damage to PLATO equipment by inmates. In fact, the inmates seem to respect an opportunity to learn. Those individuals who may have been "turned off" by formal educational systems, seem to enjoy using the PLATO mastery-based materials. In fact, waiting lists for admission to computer-based instruction are not uncommon.

Two early challenges have been met. First, the computer system was modified to keep inmate students from communicating with one another via PLATO. Second, a management system was developed on which prison teachers could become proficient with a minimum of training.

Curriculum Development

Reading Curriculum:

The Reading Curriculum is composed of three major areas:

1. Reading Comprehension

   The Reading Comprehension Curriculum, partially developed under a grant from the Illinois Office of Education (1976-1977), consists of 40 one-hour lessons designed for educationally disadvantaged youth and adults whose performance levels are between 4th and 8th grades. This pilot series of lessons focuses on developing literal, paraphrase, and inferential comprehension skills. In order to ensure the generalization of these skills (as opposed to simply memorizing answers), a sentence and paragraph generator was developed that is capable of producing 122 million different sentences, each semantically and grammatically well formed.

2. GED Reading

The GED Reading Curriculum (developed during 1982 and early 1983, partially funded by a grant from the U.S. Department of Labor) consists of 25 science and social science lessons, each lesson providing approximately 3 hours of instruction. Based on the "Advanced General Education Program: A High School Self-study Program" developed by the Department of Labor for use in the Job Corps, each lesson consists of three sections:

a. a 1,000-word passage with inserted comprehension questions,

b. a content drill, which is taken one day after completing the passage, and

c. a visual-spatial summary drill, which is taken one day after coming to criterion on the content drill.

This curriculum has as primary goals the learning of new information and the expansion and refinement of reading comprehension and study skills. To these ends, the lessons provide:

a. an on-line lexicon to aid the passage reading,

b. questions inserted in the passage text to check comprehension and develop search and study skills, and

c. delayed drills and a mastery criterion that encourage retention over time (learning and review will take place over a minimum of 3 days).

3. Finding the Main Idea

Finding the Main Idea is a series of 20 lessons, each lesson providing 30 to 45 minutes of instruction. Developed during 1981-1983, this group of lessons is based on recent research in reading comprehension. The lessons, sequential in nature, progress from finding topics for groups of related words to finding the main idea for paragraphs. A reading game is used to sharpen students' skills in applying the strategies for finding a main idea. Individualization based on student performance makes it possible for students who need extra work to get it, while students with less need will receive a lighter treatment.

Language Curriculum:

The PCP language program is composed of 40 lessons, totaling approximately 30 hours of instruction. Developed as part of an ongoing project funded by the Illinois Department of Corrections and the U.S. Department of Labor,

the primary goal of the curriculum is long-term mastery of the basic language skills associated with the Test of Adult Basic Education. The lessons, which cover spelling, grammar and mechanics, are designed for adult populations functioning at the 6th grade level and above.

Mathematics Curriculum:

The mathematics basic skills sequence covers the arithmetic of whole numbers, fractions, and decimals, with an emphasis on fractions. Developed in the mid-1970s by a number of groups, mainly with support from the National Science Foundation, many of these lessons automatically adjust in difficulty on the basis of the student's performance, and require mastery level performance for completion. A parallel set of paper-and-pencil materials fosters transfer of skills from the computer to the standard pencil-and-paper setting and provides occasion for instructors to inspect and judge student work directly.

In a preliminary evaluation study, inmates in PLATO classes had standardized test math gains twice as large as those in non-PLATO classes. Statistically, these results were highly significant, although because of the naturalistic (i.e., uncontrolled) character of the study, they can currently be taken as no better than suggestive.

Advanced topics include algebra, metrics, and trigonometry. These, and related topics outside of mathematics proper, such as accounting, physics, and computer science, are assigned on an ad hoc basis by the instructor.

SYS IV Instructional Management System

SYS IV, an instructional management system that includes several innovative and powerful features, has been in use since March, 1982. It is the latest version of a series of management systems developed since 1975 by PCP.

SYS IV includes two modes of operation: Instructor and Student. The Instructor mode may be broken down into several levels, from Instructor Aides, with a minimum of management options, to Group Directors, who have all the available options. For an instructor, options are available to read and write notes (directly to the students and also to the PLATO community as a whole), to see the instructional materials catalog, to manage student records, or to see any available PLATO lesson. While managing student records, an instructor may perform any of a large number of functions, including the creation and deletion of student records, assignment of instructional materials, and checking on a student's progress in tests, lessons, and other activities. Information about individual students is continually summarized, so that fine detail is available on recent student activity, but only a basic summary is kept for long-term storage. This allows the instructor to maintain an overall picture of how the student is doing and what he has done, without sacrificing any information needed to make decisions based on his current work. Also available is the Implementation Scan Utility, which can analyze student

data in many complex and diverse ways, and which produces either prints of student records or statistical summaries.

The student mode allows a simple choice among several alternatives, usually a selection of topics to work on, and sometimes a selection of lessons within a topic. A student also may send a note to his instructor at any time, or check on his own progress.

At the very heart of SYS IV is Instructor Logic--a computer programming language developed especially to control student progress through potentially complex curricula in a flexible and intelligent way. Instructor Logic includes features to allow reporting to the instructor on student performance, the administration of tests with control decisions based on the results, "wait" states in which the instructor must decide what the student should do next, and many other options to provide a large number of possible curriculum structures.

PCP Instructional Design Research

The substantial commitment of the PLATO Corrections Project to curriculum development extends to research in instructional design. An assumption underlying all PCP curriculum development is that lesson design must be guided by well-established instructional design theories in order to have any potential for contributing to the field of curriculum development in general.

The great majority of PCP curricula is developed in accordance with a school of instructional design most frequently referred to as "instructional systems design." Systems design is characterized by an integrated plan of instructional development that incorporates various components of instruction, such as goals and objectives formulation, pretesting, lesson design, and evaluation. Many of the features of systems design were first or most exhaustively articulated by researchers at Florida State University, including Robert Gagné, Leslie Briggs, Walter Wager, Walter Dick, and others.

A subsystem of systems design is the development of original instructional material. This subsystem involves the detailed analysis of tasks and the development of strategies for communicating new cognitive skills to the learner. For this aspect of systems design, PCP relies heavily upon the theory of Siegfried Engelmann, and to a somewhat lesser extent, the theories of Susan Markle and Robert Gagné.

A major objective of PCP has been to incorporate the above instructional design theories into a design model specifically suitable for computer-based instruction. The theoretical basis for such applications is weaker than that for noncomputerized applications. On the one hand, the research literature reflects widespread agreement on global goals of computer-based instruction: response sensitivity, adaptiveness, individualization. The specific means of achieving these goals, however, are subject to a great deal of further research and refinement.

PCP has developed a model of computer-based instructional design that explicates in detail specific means for achieving widely held goals for computer-based instruction. Some features of the model are direct applications of features of systems design, such as evaluation and lesson revision. Other features are unique to the PCP model.

Most notable among the unique features of the PCP model are those that accommodate response sensitivity (and, concurrently, adaptiveness and individualization). A response-sensitive lesson is one that continuously and contingently changes, according to the nature of specific responses of individual students. The PCP model accommodates a number of such response-sensitive changes:

1. practice variable: application items that are missed by students imply the need for more practice on that item or on items of that type. The model ensures that students whose performance indicates the need for more practice get that practice. Because this feature is implemented on an item-by-item basis, students get additional practice exactly where they need it, and never on item types for which mastery has been demonstrated.

2. increasing ratio review: this feature of the model accommodates the fact that retention is achieved most efficiently when it is "shaped" over time. When students' performance indicates a lack of retention, practice is provided at intervals that are short to begin with and then are gradually lengthened.

3. discrimination training: when students' performance indicates a confusion between two items or item types within a set, they are immediately given instruction designed to communicate the discriminating features of the confused items.

4. variable feedback: many tasks allow for wide divergence among the possible wrong (and, sometimes, right) responses. Two students who respond incorrectly but differently to the same task are likely demonstrating different misunderstandings, implying the need for different instructional feedback. The PCP model accommodates the delivery of a broad range of instructional feedback, delivered contingently upon the performance of any single student.

Features 1-3 above have been incorporated into a single computer-based utility called the "Corrective Feedback Paradigm" (CFP), developed by Siegel and his associates. Substantial empirical research has been conducted on CFP, verifying its effectiveness and efficiency for achieving mastery and long-term retention. Lessons incorporating CFP are adaptive in the sense that CFP lessons adapt themselves according to information

"learned" by the computer from student responses. Such lessons are individualized to the highest possible extent: rarely, if ever, do any two students receive the same instruction from a single CFP lesson. More important, the instruction students do receive is custom-tailored to each student's particular, demonstrated needs.

Future Plans

The PLATO "Cluster System" is being developed by CERL, so that a larger number of people will have access to the program at less cost. Work is progressing on a table-top mainframe that will run up to 100 terminals without constant phoneline and computer-usage costs. The PCP Curriculum and the SYS IV management system are being translated for use on Cluster.

As funds become available, it is anticipated that the PCP service will be expanded to all adult and juvenile correctional facilities in Illinois, and to other special populations in schools and adult education centers.

An ongoing research goal of PCP is to implement, test, and refine its model of computer-based instructional design. Present research indicates a great deal of promise for this approach.

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Siegel, M.A., & Misselt, A.L. An adaptive feedback and review paradigm for computer-based drills. Journal of Educational Psychology (in press).

Alessi, S.M., Siegel, M.A., Silver, D., & Barnes, H. Effectiveness of a computer-based reading comprehension program for adults. Journal of Educational Technology Systems, 1982-83, 11(1).

Siegel, M.A. Teacher's guide to the PCP Reading Comprehension Program for Adolescent and Adult Learners. Urbana, IL: Computer-based Education Research Laboratory, CERL Report E-3, January 1979.

Siegel, M.A. Computer-based education in prison schools. Journal of Educational Technology Systems, 1978-79, 7(3), 239-256.

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THE PLATO MATHEMATICS PROJECT

1982-83 Staff

Sharon Dugdale, Director; David Kibbey; and Tom Layman

Funding Sources

National Science Foundation; Control Data Corporation; and IBM

Overview

The mathematics project is involved in courseware research, development, implementation, and evaluation in basic mathematics. Courseware development began in 1972 under a grant from the National Science Foundation. Since that time, the project has been involved with the local public schools as a part of the daily classroom mathematics program for approximately 1800 intermediate grade students. This student usage has included various special education situations, among them hearing impairment, orthopedic impairment, and behavioral disorders. A total of about 80,000 hours of instruction has been delivered in these classrooms over the past ten years.

The curriculum developed in conjunction with this classroom use and testing includes about 250 PLATO lessons plus accompanying teachers' manuals and off-line booklets and worksheets. The curriculum includes lessons of various types for instruction, practice, and experience. The materials are highly interactive and encourage creative student responses and the sharing of strategies and ideas among students. The curriculum management system is designed for use by the busy classroom teacher with no computer experience but allows for as much involvement in the process as the teacher chooses.

The program has been well received by both students and teachers, and achievement results over several years of testing have been gratifying. The average gain in mathematics achievement for all PLATO math students during the 1976-77 school year was two full grade equivalents, as measured by the Comprehensive Test of Basic Skills. This result was replicated during the 1977-78 school year, using the Metropolitan Achievement Test. The materials developed have been used also in other programs locally and throughout the PLATO network.

In 1980, the project completed development of a package of mathematics materials for secondary level students in beginning science courses. Control Data Corporation contributed funding for this package, which covers some areas of mathematics necessary to the study of science.

Descriptions of the mathematics project and courseware may be found in the selected bibliography appended to this report.

Qualitative Interpretation of Graphs for Students of Basic Sciences

Interpretation of graphs of physical phenomena is basic to work in sciences and engineering. There is evidence, however, that students in introductory science courses have difficulty conceptualizing functional relationships as described by graphs. Students may attend to the accuracy of the numerical values without acquiring a sense of the general relationship represented.

This project, funded by the National Science Foundation and IBM, is developing a set of microcomputer activities to improve students' understanding of the qualitative aspects of graphs. Activities that orient students to interpreting qualitative graphs will be complemented by carefully constructed models that provide students experience using the qualitative aspects of graphs to accomplish a desired goal.

The materials are being designed so that they may be used in conjunction with a variety of introductory science courses at the secondary or college level or for individual study not related to a formal course.

Prototype Microcomputer Courseware for Teaching High School Algebra

This project, funded by the National Science Foundation, is developing prototype materials to teach high school algebra. The target areas are recognition of general functional relationships and graphing of linear and quadratic equations. The materials use an "intrinsic models" approach. This approach uses motivating activities that are direct expressions of the underlying mathematics.

The courseware is designed for and tested on a color graphics microprocessor-based system recently developed at CERL. After conversion to other microcomputers, the materials are being published through Conduit, P.O. Box 388, Iowa City, Iowa, 52244. Our intrinsic models approach and one of the programs are described in the publication, Green Globs (see citation below).

Selected Bibliography

Dugdale, S. Green globs: A microcomputer application for graphing of equations. Mathematics Teacher, March 1982.

Dugdale, S., & Kibbey, D. Elementary mathematics with PLATO (2d Ed.). Urbana, IL: Computer-based Education Research Laboratory, University of Illinois, July 1977.

Publications related to work with handicapped students or creative interactions among students:

Dugdale, S., & Vogel, P. Computer-based instruction for hearing impaired children in the classroom. American Annals of the Deaf, October 1978, pp. 730-743.

Dugdale, S. Using the computer to foster creative interaction among students. Proceedings of the Association for Educational Data Systems Seventeenth Annual Convention. Detroit, Michigan, May 1979. (Also published as CERL Report E-9, 252 Computer-based Education Research Laboratory, University of Illinois, 103 South Mathews Avenue, Urbana, Illinois 61801.

CONTINUING STUDY OF THE USE OF COMPUTERS IN MATHEMATICS INSTRUCTION

1982-83 Staff

Robert B. Davis, Director

Funding Sources

National Institute of Education; National Science Foundation.
No external funding after March 31, 1983

Overview

The Continuing Study of the Use of Computers in Mathematics Instruction is an ongoing activity, supported when possible by external grants, which deal with various short-term components.

1. The Computer-Administered Testing Program was completed in April, 1981. (N.I.E. funding)

2. A project concerned with the learning of fractions has been supported by N.I.E. (grant NIE-G-80-0098). The final report is now being completed. (Project terminates 3/31/83)

3. A study of the roles of "understanding" in mathematical performance was completed in April, 1982. (National Science Foundation support)

4. The two major activities at present are:

   a. Continuing cognitive studies of how students think about mathematics;

   b. Exploring the use of computers as a tool that students can use. [E.g., using ccplot to find roots of polynomial equations, etc.]. This use is very different from typical CAI use. [We also hope to explore the use of the Microsoft mu-Math.]

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Andert, K., Davis, R. B., Kumar, D., & McKnight, C. Assessing student knowledge by task-based interviews and other methods. (Final Report of NIE G-79-0141 project) April 10, 1981.

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Davis, R. B. Learning mathematics: The cognitive science approach to mathematics education. London, England: Croom-Helm (in press).

Davis, R. B. Learning fractions. (Final Report of NIE Project NIE-G-80-0093) (in preparation).

Davis, R. B. Mental representations and problem-solving success. Paper presented at A.E.R.A. meeting, Montreal, Canada, April 15, 1983.

Note: Some of this work has been translated into Italian, some into Dutch, some into Arabic, and some into Japanese. Articles referring to this work, with considerable analysis, have been published (in German) in Germany. The investigators have been invited to write sections in two current encyclopedias.

HANDICAP TECHNOLOGY PROGRAM

1982-83 Staff

William J. Goodman, Director

Funding Sources

Illinois Governor's Planning Council on Developmental Disabilities

Program Orientation

The Handicap Technology Program is a specialized research and educational component of the PLATO Education Group. Its function is to explore: A) PLATO's hardware capabilities for addressing the functional and individualized needs of physically handicapped students, B) to document the subtle sociological correlation of learned helplessness versus scholastic achievement in relation to eventual employment, and C) expand and apply the interactive communications resources of PLATO's central memory to the demanding requirements of an educational environment. Having the interactive communications resources of central memory is but one-half of the bilateral exchange of information between teacher and student. Completing the other half of the educational picture involves not just the development of hardware designed to meet the functional requirements of a broad range of handicapping conditions; for example, the orthopedically handicapped and the developmentally disabled, but necessitates creative use of the text editor, graphics processor, personal notes option, and etc. of PLATO.

Outreach

The above principles are currently being tested in a cooperative project between the Special Education District for Piatt & Macon Counties in Illinois and the Handicap Technology Program. The project has a total of six terminals. One terminal is based at William Harris School in Decatur. A text printer and a graphics copier are part of the terminal installation at the school. This hardware configuration enables the teaching staff at William Harris to transfer the completed homework assignments of their handicapped students on to paper. The remaining five terminals have been distributed to the homes of five handicapped students. All six terminals are inter-connected via telephone lines. The telephone lines supplying data to each of the six terminals are, in turn, carrying data from the central computer in Urbana.

All of the students selected for the research project have an educational handicap. It is attributable to their inability to use a pencil or a typewriter keyboard. The IST microprocessor terminal makes it possible for the orthopedically handicapped student to exploit fully the interactive communications resources of the University of Illinois PLATO system via the PPTK alternative keyboard (1).

(1) Goodman, W. J. The PLATO System, An Alternative Keyboard Using the PLATO Computer-based Education System for the Orthopedically Handicapped. Urbana, IL: Computer-Based Education Research Laboratory, PLATO Education Group, University of Illinois, May 1981.